TECHNOLOGY TRANSFER

NASA Technology Helps Patients on Earth and Addresses Fundamental Questions on Human Autonomic Function

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Dysautonomia is a term used to describe a wide variety of disorders in the human autonomic nervous system (ANS). An example of one such condition is Chronic Intestinal Pseudo-Obstruction Syndrome (CIPS), a rare disease of gastric dysmotility—the cause of which is unclear and for which pharmaceutical treatments are often ineffective. Symptoms of CIPS including nausea, vomiting, bloating, gaseousness and abdominal pain, and hypotension (low blood pressure) leave many patients with a very low quality of life. The primary purpose of this research is to determine if Autogenic-Feedback Training Exercise (AFTE) will provide relief from the symptoms of nausea and/or hypotension.

AFTE is a physiological conditioning procedure developed at Ames Research Center as a treatment for motion and space motion sickness. This method has been shown to reduce or eliminate the symptoms of motion sickness, and can be used to train control of blood pressure as a potential

Fig. 1. An Autogenic Feedback Training Exercise (AFTE) test with a patient whose autonomic nervous system no longer functions properly. AFTE reduced her symptoms of nausea and improved (restored) gastric function.

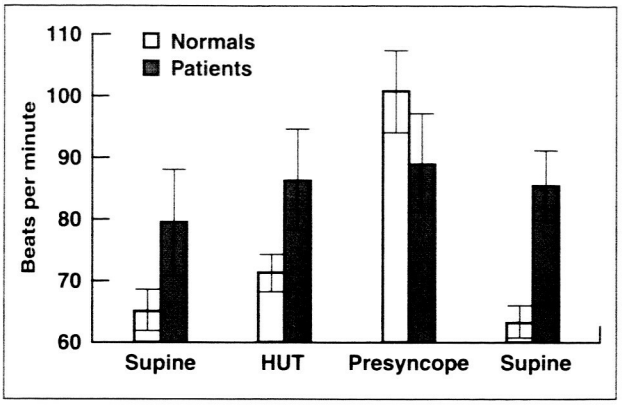

Fig. 2. A comparison of the average heart rate responses of normal subjects and patients during 60-degree head-up tilt (HUT) tests designed to induce presyncope (that is, just prior to fainting). N = 8 per group.

treatment for hypotension. The end result is a normalization of autonomic balance (see figure 1).

One of the first steps in this project was to determine differences in autonomic function between normal subjects and patients. Changes in physiological responses were measured during tests designed to induce the early symptoms of presyncope, for example, dizziness, and lightheadedness experienced just prior to fainting. The stimulus used for patients was a 60-degree head-up tilt (HUT) table test (figure 2). A much stronger stimulus of HUT combined with lower-body negative pressure (HUT + LBNP) was required to produce presyncope in normal healthy subjects who rarely reach presyncopal symptoms in response to 10-minute exposure to 60-degree HUT alone. The higher resting level of heart rate in CIPS patients during pretest baseline (supine), and their smaller heart rate increases in response to stimulation when compared to normal subjects, illustrates one aspect of autonomic dysfunction presented by patients with this diagnosis.

Physicians at the University of Tennessee have initiated AFTE trials with 23 patients. Following training, 78% of patients reported a reduction in gastric discomfort, with an associated "normalizing" of their gastric motility observed in electrogastrogram measures in 52% of the cases. However, only 26% showed an improvement in blood flow adjustment to posture. One possible explanation is that the patients received more training for control of gastrointestinal than cardiovascular responses, or that the

training effects were specific to gastrointestinal function in these patients. A second explanation concerns the training schedule and tools employed by University of Tennessee physicians, where too long an interval between lessons may have led to "forgetting" of learned responses and indicated the necessity for relearning.

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Perceptual Impact of Predictive Compensation for Time Delays in Virtual Environments

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In visually presented virtual environments (VE), measured displacement of the observer's head is used to position and orient the viewed simulation content in head-mounted or other types of video displays. Because of latencies within and between individual VE system hardware and software components, time delay in rendering the visual consequences of input

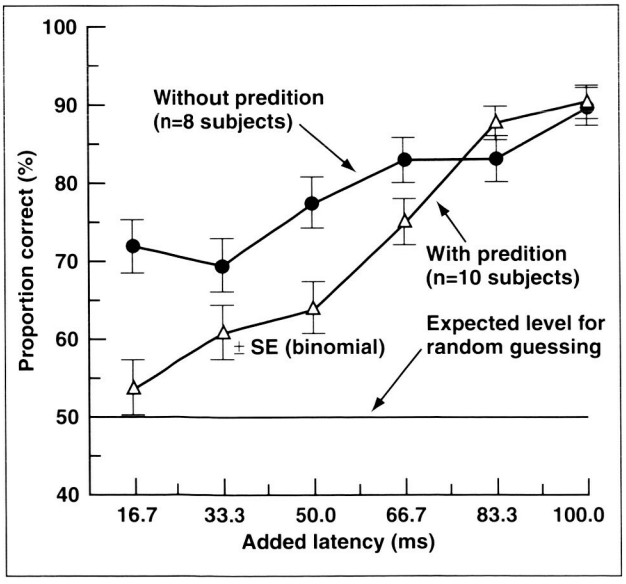

Fig. 1. Generic predictor and uncompensated VE discriminability.

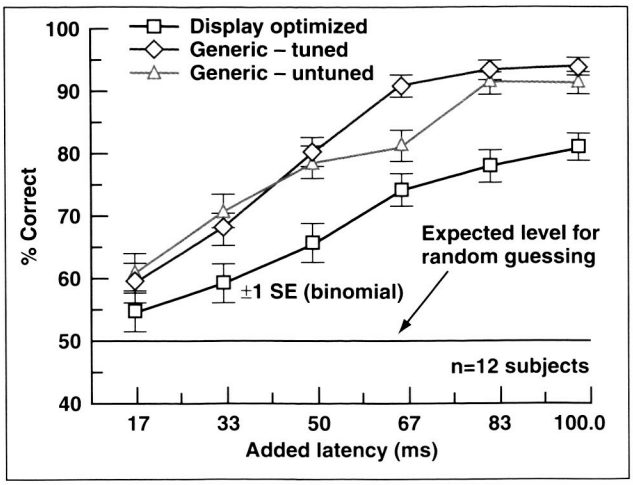

Fig. 2. Discriminability of different predictor designs.

motion is unavoidable. These delays disrupt image stability and, therefore, can disturb the observer's sense of presence and ability to perform useful work in a VE. Predictive compensation software, by extrapolating ahead in time, offers means to mitigate the consequences of VE delays. However, prediction introduces noise and overshoot artifacts into measured human motion that can be as perceptually disruptive as the original uncompensated VE time delay. The immediate objective of this work is to ascertain the perceptual impact of artifacts arising from predictive compensation of VE time delay, and ultimately to use this understanding to guide the design of novel compensation schemes.

A psychophysical method was developed that has allowed the first experimental assessments of the direct perceptual impact of VE motion artifacts induced by different predictive compensation schemes. In the experiments, subjects move their heads in a stereotyped periodic motion while viewing a VE that contains a single, simple, stationary object. Under one condition, the VE operates at its baseline latency. Under the second condition, an artificially added time delay is predictively compensated back to the baseline. In principle then, overshoot, noise, and any other artifacts of imperfect prediction should be the only source of discernible differences between the two. Subjects